Assessing the Impact of Nitrogen Fertilizer Amounts and Sources on Strawberry Yield and Shelf Life

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Context of Nitrogen Management for Strawberry production in Ventura County:

- Concerns with environmental contamination and regulations; NMP requirement
- Concerns with fruit quality and shelf life
- $\text{NO}_3^- \text{ vs NH}_4^+$-based fertilizers
- Concerns that N-induced excessive vegetative growth can reduce yields
- Crops are often under-fertilized and yields reduced to avoid excessive vegetative growth and shelf life issues
- Limited N uptake information in Ventura County (restricted funds availability)
- Cultivars may respond differently to varying N amounts
- Long season (approx. 9 months), variable rainfall
Strawberries in general:

- Sensitive to mild water stress (increased irrigation frequency)
- Shallow, or relatively shallow root system
- Usually grown on well-drained soils
- High-value crop; small yield losses can cause significant impact on returns

Most soil N is in the form of nitrate
- Nitrate is very soluble in water
- Nitrate is weakly held in the soil CEC

Typical number of irrigation events: 50-60

https://apps1.cdfa.ca.gov/fertilizerresearch/docs/Nitrate_Tool.html
A majority of agriculture wells on the Central Coast are contaminated with nitrate.
Nitrogen Use Reporting

Responsibility Areas

Farm Bureau of Ventura County:
http://www.farmbureauvc.com/issues/water-issues/water-quality/management
Establishment,
up to 1/3 of crop cycle

- Very little N uptake
- Little water demand, but high susceptibility to water stress
- Shallow root system

Remaining 2/3

- Constant N uptake rate (predictable)
- Increasing water demand
- Increasing and deeper root system

Right Rate
Right Time
Objectives

➢ Quantify yield and shelf-life responses do distinct N fertilization amounts

➢ Quantify yield and shelf-life responses do ammonium and nitrate-based fertilizers

➢ Determine if increased vegetative biomass decreases yield
Material and Methods

✓ 6 treatments: 3 rates (low, medium and high), 2 fertilizers (CN9 and AN20)
  CN9 = Calcium nitrate (93.5% NO$_3$-N, and 6.4% NH$_4$-N) + 11% Ca
  AN20 = Ammonium nitrate (50% NO$_3$-N and 50% NH$_4$-N)

✓ Treatments were fertigated on average every 17 days

✓ Cultivars: Fronteras and Proprietary cv.

✓ 64 in bed, two high-flow tapes, planted on October 8, 2018

✓ No pre-plant fertilizer applied

✓ Soil NO$_3$-N before planting: 2.4 ppm at 0-12 in depth

✓ Soil Ca: 17.3 meq/100g

✓ Soil: Hueneme sandy loam
Material and Methods

- Experimental design: randomized complete block, replicated four times; 30 ft long and 1 bed wide plots

- Soil, leaf blades and fruits were sampled periodically (5 times) and analyzed for total N and Ca concentrations

- Total drip-applied water: 14.0 in; total precipitation: 16.8 in;

- Canopy cover and vegetative biomass

- 42 harvest events: marketable and unmarketable yield and berry weight

- Shelf life: fruit firmness, weight loss, mold, leakage at 0, 4, 8 and 12 days (St Francis Cooler, Oxnard). March, April and June

- Cooler Temperature: 33F, Relative humidity: 86%
## Treatments

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>----- lbs N/ac/week -----</strong></td>
<td>-----</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Early season (Oct-Feb)</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Late season (Mar-May)</td>
<td>6</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td><strong>------- lbs N/ac -------</strong></td>
<td>-----</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Total applied (Oct 8-May 31)</td>
<td>118</td>
<td>208</td>
<td>298</td>
</tr>
</tbody>
</table>

Applied as CN9 and as AN20
Treatments

Cumulative Fertilizer Rates of Treatments and Rainfall Events

- Low
- Medium
- High

Rainfall (in)

Lbs N/ac

- Soil and leaf blade sampling events
- Fruit sampling and shelf-life assessment events
Early season, lower rates

Mid-late season, higher rates
Plot map:
Results
Total Marketable Yield, Fronteras

F
5.58
Prob > F 0.0037

Boxes/acre

Low Medium High Low Medium High

------------------- CN9 -------------------

------------------- AN20 -------------------
Marketable Yield, Fronteras

December to February

March to June

Boxes/acre

Low  | Medium  | High

Low  | Medium  | High

CN9  

AN20
Total Marketable Yield, Proprietary cv.

![Boxplot showing the total marketable yield for different levels of CN9 and AN20.

- **CN9**: Low, Medium, High
- **AN20**: Low, Medium, High

The yields are measured in boxes/acre. The boxplot indicates the distribution of yields for each level with significant differences indicated by different letters (a, ab, b). The F-value is 3.29 with a Prob > F of 0.0292, suggesting a statistically significant difference among the levels.]
Concentration of Leaf Blade Nitrogen, Fronteras

- Low CN9
- Medium CN9
- High CN9
- Low AN20
- Medium AN20
- High AN20

Total N (%)

2.5 2.7 2.9 3.1 3.3 3.5 3.7 3.9

26-Nov 26-Dec 25-Jan 24-Feb 26-Mar 25-Apr 25-May
Concentration of Leaf Blade Nitrogen, Fronteras

- Low CN9
- Medium CN9
- High CN9
- Low AN20
- Medium AN20
- High AN20

Total N (%)

2.5 2.7 2.9 3.1 3.3 3.5 3.7 3.9

26-Nov 26-Dec 25-Jan 24-Feb 26-Mar 25-Apr 25-May
Concentration of Leaf Blade Nitrogen, Proprietary cv.

Total N (%)
Soil Mineral Nitrogen (NH4 + NO3), Proprietary cv.

N (ppm)

Low CN9  Medium CN9  High CN9
Low AN20  Medium AN20  High AN20

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Agriculture and Natural Resources
NO₃-N at 12-24 in depth

ppm

- Fronteras
- Proprietary cv.

Low CN9  Medium CN9  High CN9  Low AN20  Medium AN20  High AN20
All cultivars soil pH, 0-12in depth
Canopy Coverage

**Fronteras**

- Jan: Low CN9, Medium CN9, High CN9
- Mar: Low AN20, Medium AN20, High AN20
- Apr: Low CN9, Medium CN9, High CN9
- May: Low AN20, Medium AN20, High AN20
- Jun: Low CN9, Medium CN9, High CN9

**Proprietary**

- Jan: Low CN9, Medium CN9, High CN9
- Mar: Low AN20, Medium AN20, High AN20
- Apr: Low CN9, Medium CN9, High CN9
- May: Low AN20, Medium AN20, High AN20
- Jun: Low CN9, Medium CN9, High CN9
Fronteras, Dry Aboveground Biomass (grams/8 plants)
Yield vs Vegetative Biomass, Fronteras

R² = 0.9675
Proprietary cv., Dry Aboveground Biomass (grams/8 plants)
Yield vs Vegetative Biomass, Proprietary cv.
Shelf Life Results

✓ Treatments did not affect fruit firmness, mold, leakage and berry weight; no trends observed

✓ Leakage and mold were observed in June at 8 and 12 days, but data is inconclusive
Summary

✓ Fronteras yield for Medium and High AN20 was very similar and significantly greater than Low CN9 and Low AN20. All other differences were not statistically significant.

✓ Cull rate and shelf life were not affected by fertilizer rates and sources.

✓ Significantly high precipitation amounts were atypical and most likely influenced results.

✓ Fronteras yield was clearly correlated with vegetative biomass; proprietary cv. was not.
Nitrogen and Calcium content in whole fruits was not affected by fertilizer rates and sources; calcium content in leaf blades was not affected by treatments in both cultivars.

Concentration of leaf blade N was significantly affected by treatments in March, April and June samplings.

There were significant differences in cultivar response to treatments. Research is needed for other cultivars.
Other observations:

✓ Ca in the leaf blades and fruits were very similar and didn’t present a trend between fertilizer types (CN9 vs. AN20)

✓ Overall leaf blades nutrient content in June were greater for AN20; Mn was significantly (P<0.05) greater for AN20 than CN9 for both cultivars

✓ Soil pH differences between fertilizer types and rates at crop termination were minimal (<0.02) and not statistically significant
Acknowledgements:

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Questions/comments?